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(54) HIGH STRENGTH AND HIGH TOUGHNESS WEAR RESISTANT STEEL

(57)Abstract:
PURPOSE: To improve wear resistance at high temp., strength and toughness by specifying the amts. of C, Si, Mn, P, S, Cr, Mo, V, B, etc.
CONSTITUTION: This steel has a compsn. consisting of, by weight, 0.35-0.55% C, ≤0.5% Si, ≤0.5% Mn, ≤0.015% P, ≤0.01% S, 1-2.5% Cr, 1-2% Mo, 0.05-0.3% V, 0.0003-0.005% B, 0.005-0.1% Al, 0.005-0.2% Nb and the balance Fe or further contg. 0.01-0.15% Zr and/or 0.01-0.1% Ti, has ≥250 Rockwell hardness (HRC), such high strength as ≥180kgf/mm2 tensile strength and high toughness by tempering to 500°C, and is used for the edge of the excavating blade of civil engineering and construction machinery, etc.

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CLAIMS

[Claim(s)]

[Claim 1] At weight %, it is C. : 0.35 - 0.55% Si: 0.50% or less, Mn: Below 0.50 %, P: Below 0.015 % S: Below 0.010 % Cr : 1.00 - 2.50%, Mo: 1.00 - 2.00%, V: 0.05 - 0.30% B: 0.0003 - 0.0050%, aluminum: 0.005 - 0.10% Nb : It is the steel for high intensity high toughness antifriction which contains 0.005 - 0.20% and has the steel presentation from which the remainder consists of Fe and an unescapable impurity substantially.

[Claim 2] Furthermore, Zr: 0.01 - 0.15%, and/Or Ti: Steel for high intensity high toughness antifriction containing 0.01 - 0.10% according to claim 1.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the steel for high intensity high toughness antifriction with good high intensity used for the edge of a blade for drilling, such as an engineering-works construction equipment, etc., toughness, and abrasion resistance in an elevated temperature.
[0002]
[Description of the Prior Art] The Lipper point of a bulldozer is mentioned as an example representing the drilling edge of a blade of an engineering-works construction equipment. This is attached in the excavator style specially established on the bulldozer, is stuffed into a base rock, and breaks a base rock. Drawing 1 shows this Lipper point with a shank. For the Lipper point 1 among drawing, it is attached in a shank 2 and this shank 2 is the excavator style (not shown) of a bulldozer. It is equipped.
[0003] as the need property of the steel conventionally used for such the drilling edge of a blade -- two or more 150 kgf/mm tensile strength, 50 or more hardness HRC, and Charpy-impact-value 5 kgf-m/cm2 the above -- and it having been needed that a bending property is good, having satisfied this, and having been used widely -- nickel-Cr-Mo system low alloy steel (JIS SNCM240 grade) it was . However, the operating environment using such the drilling edge of a blade also becomes every year more cruel, and the property required of the steel used for the drilling edge of a blade in connection with it is also severe.
[0004] for example, the case where a hard base rock is excavated using the Lipper point -- the skin temperature of the Lipper point -- a maximum of -- since it reaches more than 450 ** -- conventional JIS In SNCM240, lowering of hardness is large and wear becomes intense. However, if hardness level is raised for wear-resistant improvement at an elevated temperature, **** etc. will occur with the bending stress at the time of an activity shortly.
[0005] Although toughness and the abrasion resistance in an elevated temperature are good and excellent in the hot-working nature at the time of the manufacture, as recent years, when a service condition is severe, the field of reinforcement and toughness of such steel is not so enough as the steel for drilling with which the proposal is made by JP,60-25498,B etc., either, and an OFF.disadvantage, intense wear, etc. generate it. Moreover, such steel is high alloy steel, and it is not economical that there is the need of making hardening temperature high etc. And development of the steel type which was excellent rather than the demand of much more extension of the activity life from a need person, a cost cut, etc. was also strong and satisfied with recently of each of those demands is called for.
[0006]
[Problem(s) to be Solved by the Invention] Therefore, the general objects of this invention are high intensity and high toughness, and are that the abrasion resistance in an elevated temperature offers good steel. tempering temperature since, as for the concrete object of this invention, the service temperature of the Lipper point reaches more than 450 ** -- more than 500 ** -- tensile strength 180kgf/mm2 the above -- 50 or more hardness HRC and Charpy-impact-value 5 kgf-m/cm2 the high intensity and high toughness whose amount of deflection of a bending property it is above and is 30mm or

more -- and the abrasion resistance in an elevated temperature is offering good steel.
[0007]
[Means for Solving the Problem] In order to obtain the steel which has such a need property, as a result of repeating an experiment and research wholeheartedly, this invention persons did the knowledge of it being effective to satisfy the following conditions, and completed this invention.
** The consolidation of a grain boundary is attained by relief of the grain boundary segregation by low [P] and the reduction in S and defecation, and forming low Mn further, and be effective in the improvement in toughness.
** Grain refining of steel should be remarkably promoted by loading and Nb addition of Mo, grain boundary segregation should be mitigated in connection with it, and improvement in toughness should be achieved.
[0008] ** Softening by compound addition of Nb, Cr, and Mo raising the resistance to temper softening of steel remarkably, being able to adopt high tempering temperature by it, and the improvement in toughness being found, and temperature rising while in use should be prevented. This invention is weight % here and it is C. : 0.35 - 0.55% Si: 0.50% or less, Mn: Below 0.50 %, P: Below 0.015 % S: Below 0.010 % Cr : 1.00 - 2.50%, Mo: 1.00 - 2.00%, V: 0.05 - 0.30% B: 0.0003 - 0.0050%, aluminum: 0.005 - 0.10% Nb : 0.005 - 0.20% is contained. Furthermore the need is accepted and it is Zr. : 0.01 - 0.15%, Ti: Containing 0.01 - 0.10% of one sort, or two sorts, the remainder is steel for high intensity high toughness antifriction which has the steel presentation which consists of Fe and an unescapable impurity substantially.
[0009]
[Function] In this invention, the reason which limited the component of steel is explained below. In addition, it is weight % unless especially % has a notice in this description.
C: Since the quench-crack susceptibility at the time of hardening increased and toughness degradation was caused in relation to other alloy contents when degradation of hardenability could not be caused at less than 0.35% 0.35 to 0.55% although C was a component required not only the reason of reservation of hardenability and reinforcement but for grain refining of the crystalline structure, and desired reinforcement could not be secured but it exceeded 0.55% on the other hand, it could be 0.35 - 0.55%. Preferably, it is 0.40 - 0.50%.
[0010] Si: 0.50%or less Si is an element effective in deoxidation of steel, and strong reservation. However, the content was made into 0.50% or less in order to segregate if it exceeds 0.50%, and to degrade toughness.
Mn: Although it is an element effective in Mn raising hardenability outside deacidification 0.50% or less, the grain community embrittlement phenomenon made to contain so much arises, and degradation of toughness is caused. Furthermore, for the improvement in toughness, the content must be reduced as much as possible also from combining with S and the origin of a crack coming. For this reason, Mn content was made into 0.50% or less.
[0011] P: Below 0.015 % P is P, in order to be unable to disappear the grain boundary segregation thoroughly no matter what heat treatment it may perform, and to reduce grain boundary reinforcement and to degrade toughness. The content was restricted to below 0.015 %.
S: Below 0.010 % S is MnS which combined with Mn and was generated. In order for the

origin of a crack to come, to segregate to a grain boundary even when it is still more independent, and to promote embrittlement, it is required to restrict the content low as much as possible. If it is in this invention, it restricts to below 0.010 %.

[0012] Cr : Cr has the operation which the hardenability of steel is raised and gives resistance to temper softening to steel 1.00 to 2.50%. Although it had the operation which gives remarkable softening resistance especially to steel by compound addition with Mo and Nb, the effectiveness of a request of the content at less than 1.00% was not acquired, but since another side Cr was an expensive alloy element, it made the upper limit 2.50% in consideration of profitability.

[0013] Mo: 1.00 - 2.00%Mo has the operation which the hardenability of steel is raised and gives resistance to temper softening to steel, increases resistance-to-temper-softening nature remarkably by compound addition with Cr and Nb especially, enables adoption of high tempering temperature, and is effective also in an improvement of toughness. However, at less than 1.00%, said operation is not demonstrated and desired effectiveness is not acquired. On the other hand, the content was made into 1.00 - 2.00%, in order that the effectiveness might be saturated and might only cause cost lifting, even if it added exceeding 2.00%.

[0014] V: 0.05 - 0.30%V has the operation which gives resistance to temper softening, and although it is effective in coarsening prevention and wear-resistant improvement, at less than 0.05%, the operation is not demonstrated and desired effectiveness is not acquired. On the other hand, since lowering of hot-working nature, machinability, and toughness was caused when it exceeded 0.30%, the content was made into 0.05 - 0.30%.

[0015] B: It is B, in order that the effectiveness may cause degradation of the toughness of steel at less than 0.0003% if it is not acquired but 0.0050% of another side is exceeded although 0.0003 - 0.0050%B has the operation which raises hardenability and it is an element effective in reservation of high intensity. The addition was made into 0.0003 - 0.0050%.

[0016] aluminum: Under by 0.005 %, although it was a component effective in aluminum achieving stabilization of deoxidation of steel, homogenization of the crystalline structure, and grain refining 0.005 to 0.10%, since that effectiveness was saturated, and the crack occurred according to buildup of inclusion and toughness also deteriorated even if desired effectiveness was not acquired but it exceeded 0.10% of another side, it is in this invention and aluminum content was made into 0.005 - 0.10%.

[0017] Nb : 0.005 to 0.20%, Nb is effective to the reinforcement of steel, and improvement in toughness and grain refining, since it carries out grain refining of the steel remarkably by compound addition with Cr and Mo especially and raises resistance to temper softening remarkably, it is an element very effective in a toughness improvement, but in order to secure the effectiveness, it is required more than 0.005 %. On the other hand, when it exceeded 0.20%, since the effectiveness was saturated and also attached cost highly, it was made into 0.005 - 0.20%.

[0018] Zr: 0.01 - 0.15%, and/or Ti: What is necessary is just to add Zr and Ti by request 0.01 to 0.10% for a toughness improvement. Zr has the effectiveness of carrying out spherical grain refining of the carbide in steel, making it distributing, and improving toughness further. Although it was desirable to have added in order to acquire high toughness especially in the case of high-strength steel, if the effectiveness is small and exceeds 0.15% of another side, in order to cause toughness degradation rather, at less

than 0.01%, it could be 0.01 - 0.15%.
[0019] Ti also has the operation which raises the hardenability of steel much more. When especially a steel-part dimension was large, it was desirable to have made it contain in order to secure high intensity, but less than by 0.01, the effectiveness was not acquired, but if 0.10% of another side is exceeded, in order to degrade the toughness of steel, it could be 0.01 - 0.10%.
[0020] On the occasion of manufacture of the steel concerning this invention, the steel adjusted to the above-mentioned presentation is ingoted, after considering as slab by continuous casting or the ingot making method, between heat or cold working is performed suitably, after considering as a predetermined configuration, it quenches and tempering is carried out here. Thereby, it is HRC. The steel which has 50 or more degrees of hardness, two or more impact resistance value 5 kgf-m/cm, and a property with an amount [of deflections] of 30mm or more is obtained, and it becomes an ingredient suitable for using it as the drilling edge of a blade of an engineering-works construction equipment especially.
[0021]
[Example] Steel A-Q which has the component shown in a table 1 by the usual approach was ingoted. Steel A-I has the presentation of this invention within the limits among such steel, and steel J-Q is the comparison steel which separated from the presentation range which this invention specifies. After making such steel with slab by the continuous casting process or the ingot making method and heating at 1200-1250 degrees C, after rolling out to the round bar with a diameter of 30mm by the usual approach, quenching and temper were performed on the heat treatment conditions shown in a table 2. In addition, since temperature higher than it since temperature up is carried out till around 400 ** at the time of an activity was the need, annealing was taken as 500 ** regularity.
[0022] Then, it was processed into various test pieces and the property was investigated. The result is shown in a table 2. In addition, it is the test piece laid on the two supporting points 3 in the way which an impact resistance value is a Charpy test value, and shows the amount of deflection to drawing 2. (dimension: 22x20x170mm) The amount of deflection when carrying out and fracturing the bending test to which crosses crosswise [of 4] and a load is applied from an arrow head by the piece 5 of ** is shown. When the amount of deflection did not fracture by 30mm or more, it fractured and **(ed). It is clearer than the result of a table 2 that the reinforcement which the steel concerning this invention had all satisfied the target engine performance in each demand characteristics, and was excellent, and toughness are shown.
[0023] Moreover, the abrasion loss after building a prototype on the Lipper point raised as a representative of the drilling edge of a blade and using it actually about some of such steel for 1 hour was investigated. The result is shown in a table 2. Since it was the same, each service condition can evaluate abrasion resistance by measuring each abrasion loss. It became clear that each steel concerning this invention had good abrasion resistance. In addition, Steel P is equivalent to the steel indicated by JP,60-25498,B. The almost double abrasion loss of the steel concerning this invention was shown.
[0024]
[A table 1]

	No.	化学成分 (wt%)													備考
		C	Si	Mn	P	S	Cr	Mo	V	Nb	B	Ti	Zr	sol.Al	
本発明鋼	A	0.49	0.29	0.45	0.008	0.007	1.50	1.49	0.23	0.049	0.0019	—	—	0.050	
	B	0.47	0.31	0.46	0.009	0.008	2.01	1.03	0.15	0.051	0.0019	—	—	0.047	
	C	0.48	0.31	0.46	0.009	0.008	1.50	1.58	0.15	0.051	0.0020	—	—	0.047	
	D	0.40	0.08	0.10	0.009	0.007	2.48	1.98	0.30	0.150	0.0031	—	—	0.021	
	E	0.43	0.26	0.44	0.014	0.011	1.01	0.48	0.10	0.034	0.0035	0.05	—	0.051	
	F	0.55	0.15	0.21	0.010	0.010	1.48	1.30	0.12	0.030	0.0030	—	0.08	0.020	
	G	0.53	0.48	0.30	0.012	0.009	1.88	1.90	0.20	0.050	0.0020	—	—	0.018	
	H	0.43	0.31	0.25	0.009	0.008	2.15	1.10	0.18	0.098	0.0035	0.10	0.15	0.035	
	I	0.43	0.43	0.48	0.009	0.009	1.10	1.85	0.25	0.085	0.0035	—	—	0.040	
比較鋼	J	0.45	1.45	0.46	0.010	0.006	1.49	0.52	0.14	0.049	0.0018	—	—	0.045	
	K	0.57	1.45	0.46	0.009	0.008	1.01	1.03	0.15	0.053	0.0019	—	—	0.048	
	L	0.62	0.58	0.30	0.020	0.010	3.00	1.20	0.30	0.080	0.0030	—	—	0.030	
	M	0.43	0.25	0.40	0.030	0.035	1.80	0.50	0.12	0.030	0.0019	—	—	0.050	
	N	0.35	0.31	0.45	0.008	0.008	1.20	0.50	—	0.030	—	—	—	0.030	
	O	0.45	0.25	0.85	0.010	0.008	1.00	0.20	—	—	—	—	—	0.040	
	P	0.39	0.93	1.02	0.015	0.008	0.97	0.95	0.49	—	—	—	—	0.041	
	Q	0.40	0.25	0.90	0.020	0.018	0.50	0.20	—	—	—	—	—	0.050	Ni:0.50% (JIS SNCM420)

[0025]
[A table 2]

	鋼種	熱処理条件		特性			リッパーポイント1hr使用時の摩耗量 (g)
		焼入温度 (℃)	焼戻温度 (℃)	HRC 硬度	衝撃値 (kgf-m/cm²)	タワミ量 (mm)	
本発明鋼	A	910	500	50.1	8.9	破断せず	250
	B	890	500	50.3	8.5	〃	240
	C	910	500	50.9	7.9	〃	—
	D	950	500	51.6	7.6	〃	—
	E	890	500	51.6	8.1	〃	—
	F	890	500	51.4	8.3	〃	—
	G	920	500	51.4	8.0	〃	—
	H	910	500	53.1	7.3	〃	—
	I	950	500	56.5	6.7	〃	—
比較鋼	J	930	500	51.0	3.9	20	520
	K	930	500	55.2	2.8	20	—
	L	890	500	57.4	2.1	15	—
	M	880	500	45.8	5.3	15	—
	N	890	500	42.0	9.0	破断せず	—
	O	850	500	43.6	5.8	〃	—
	P	960	500	46.4	4.9	15	500
	Q	860	500	42.7	6.0	20	1500
	目標性能			≧50	≧5	≧30	—

[0026] Drawing 3 is HRC when the multiplication-effectiveness exerted on the tempering softening resistance by coexistence of Cr, Mo, and Nb being shown about each steel of this example, and considering tempering temperature as 500 ** regularity. It is estimated that softening resistance is also at a degree of hardness. the field surrounded with a broken line among drawing -- the field of this invention -- it is -- any -- impact resistance value 5 kgf-m/cm2 the above -- HRC 50 or more degrees of hardness are shown.

[0027]

[Effect of the Invention] According to [as explained above] this invention, it is 180 kgf/mm2 at 50 or more HRC(s) and tensile strength by 500 ** annealing. Since the high intensity and high toughness steel which have the above high intensity and have high toughness and a good cold-bending property can be obtained, the effectiveness it is ineffective size that it can provide for the edge of a blade for drilling, a tool, etc. which are used for an engineering-works construction equipment etc. as cheap alloy steel is done so.

[Translation done.]

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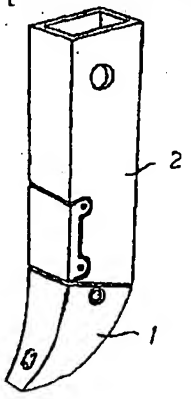
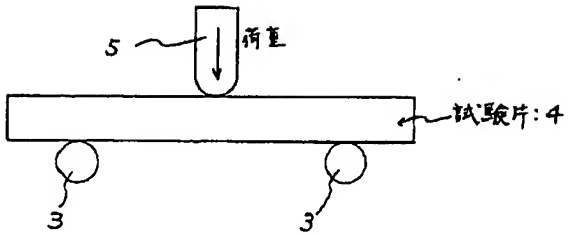
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing 1 is the informality perspective view showing the Lipper point attached in a bulldozer.
[Drawing 2] Drawing 2 is the explanatory view of the point of a bending test.
[Drawing 3] Drawing 3 is a graph which shows the coexistence effectiveness of Cr, Mo, and Nb.
[Description of Notations]
1 Lipper Point
2 Shank
3 Supporting Point
4 Test Piece
5 Piece of **

[Translation done.]




5
荷重
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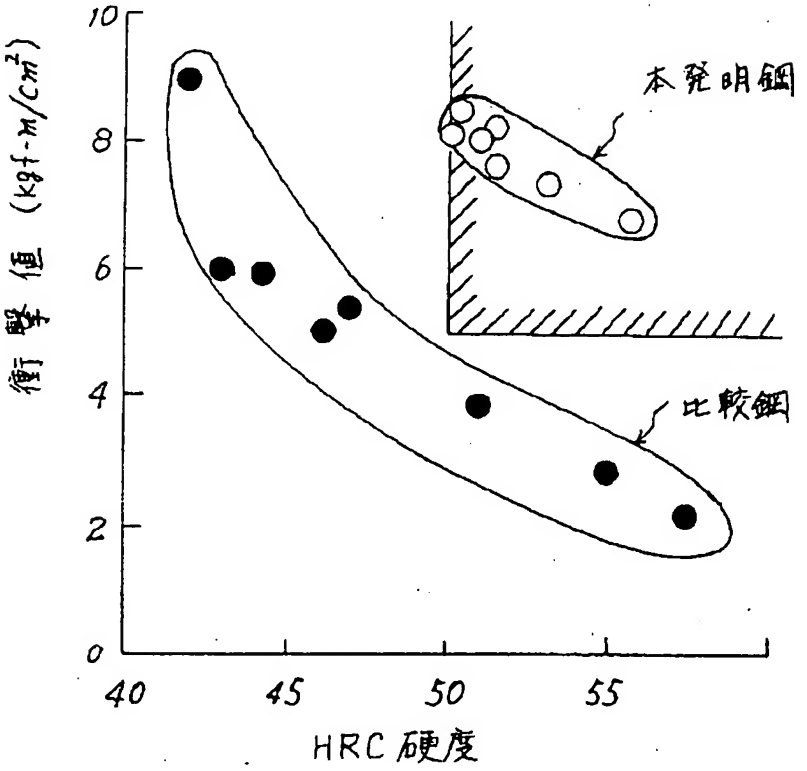
3


衝撃値 (kgf-m/cm²)
10
8
6
4
2
0
40
45
50
55
HRC 硬度
本発明鋼
比較鋼